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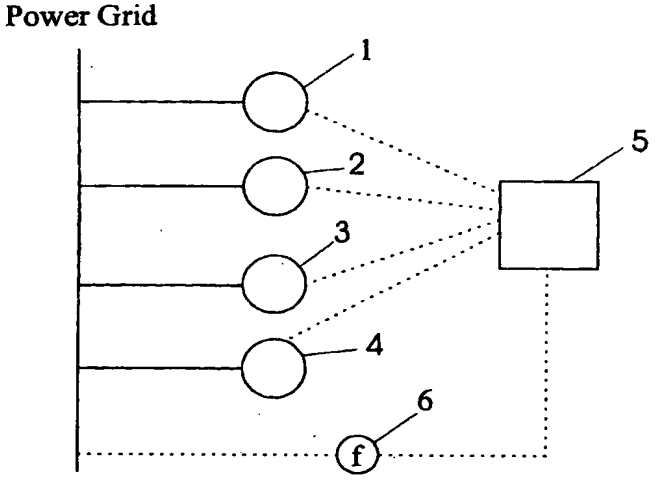
(54) Title: WIND FARM AND METHOD FOR OPERATING SAME



(57) Abstract: A wind farm with at least two wind turbines (1, 2, 3, 4) connected to a power grid is provided, said wind farm further comprising a control unit (5) connected to said at least two wind turbines (1, 2, 3, 4), and a sensor unit (6) connected to said power grid and said control unit (5), wherein said sensor unit (6) is adapted to measure the grid frequency of said power grid and to transmit said measured grid frequency to said control unit (5), and wherein said control unit (5) is adapted to control the output of real power of said wind farm according to said measured grid frequency. Furthermore, a method for operating a wind farm is proposed, said method comprising the steps of measuring the grid frequency with a sensor unit, transmitting said measured grid frequency to a centralized control unit, determining whether the measured grid frequency lies outside a predetermined range, and, if the measured grid frequency lies outside said predetermined range, selecting at least one out of the at least two wind turbines comprised in said wind farm by said centralized control unit and regulating the power output of said selected at least one wind turbine.

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Wind Farm and Method for Operating Same

Field of the Invention

The invention relates to a wind farm and a method for operating said wind farm, especially to a method for controlling the real power output of said wind farm depending on a measured variable of the power grid to which the wind farm is connected.

Background of the Invention

Nearly every power generating plant – be it a nuclear power plant, a cogeneration plant, a wind power station – generates the current by a generator which converts mechanical energy into electrical power.

Usually, the generator is connected to a power line conducting electrical current. The power line from which consumer loads connected to it obtain their power, should have a defined grid parameters, in particular, a defined voltage and a defined frequency. For example, the desired values for the average German household on the low voltage level are 230 Volts and 50 Hertz (Hz).

The stability of the grid parameters is dependent on a variety of influencing variables including the balance between generated power and the consumed power at every instant. Any imbalance between generated (real) power and consumed (real) power leads to changes in the grid frequency. When more power is generated than consumed, the frequency rises, if more power is consumed than generated, it decreases. In order to avoid overload within the combined grid systems and to control the load flow, it is vital to maintain the grid frequency fluctuation as small as possible.

As the installed power of wind turbines increases, wind power generation has an increasing influence on the grid stability. Therefore, it becomes more and more important for wind farms to contribute to the grid stabilization by controlling the real power output of a wind farm dependent on the grid frequency.

Summary of the Invention

It is therefore an object to provide an improved wind farm and a method for operating the same, in particular a wind farm which can be effectively controlled with regard to the stabilization of the grid parameters, in particular with regard to the grid frequency.

This object is solved by a wind farm according to independent claims 1 or 7 and by operating methods according to independent claims 13 and 14 as well as the procedures according to independent claims 20 and 21. Further advantages, features, aspects and details of the invention are evident from the dependent claims, the description and the accompanying drawings. The claims are intended to be understood as a first non-limiting approach of defining the invention in general terms.

According to an embodiment of the present invention, a wind farm with at least two wind turbines connected to a power grid is provided, said wind farm further comprising a control unit connected to said at least two wind turbines , and a sensor unit connected to said power grid and said control unit, wherein said sensor unit is adapted to measure the grid frequency of said power grid and to transmit said measured grid frequency to said control unit, and wherein said control unit is adapted to control the output of real power of said wind farm according to said measured grid frequency.

The above described embodiment of the present invention allows for a stabilization of the grid frequency at the wind farm level rather than at the level of individual wind turbines. The centralized control unit allows for a centralized wind farm management taking into account the actual state of the complete wind farm rather than of a single wind turbine. Thus, the centralized wind farm management allows for higher dynamics and variable feasibility in regulation to stabilize the grid frequency. Furthermore, the centralized wind

farm management allows for a selection of individual turbines according to criteria other than only frequency stabilization.

According to a further embodiment of the present invention, a wind farm with at least two wind turbines connected to a power grid is provided, said wind farm further comprising a coupling device for coupling the wind farm to the power grid, and a sensor element for sensing a first variable indicative of said wind farm wherein said sensor element is adapted to transmit said measured first variable to said coupling device, and wherein said coupling device is adapted to control a second variable of said wind farm according to said measured first variable.

The above described further embodiment of the present invention also allows for a centralized wind farm management taking into account the actual state of the complete wind farm rather than of a single wind turbine. However, by providing a sensor element that senses a specific variable indicative of the actual state of the wind farm, the regulation and control of the wind farm can be performed not only depending on the grid parameters but also on the basis of the internal state of the wind farm. In particular, not only grid parameters like, e.g. the grid frequency, may be monitored, but also setpoints for internal variables such as the actual power delivered to the grid, a maximum power setpoint or the actual voltage at the point of coupling to the grid can be monitored. Accordingly, specific setpoints which may even be prescribed by external parties like, e.g. utilities, can be observed due to monitoring and proper regulation. Moreover, the control of the wind farm may be accomplished via either the same variable as measured or by a different variable. For example, the sensor element may measure the actual voltage, but the coupling means regulates the wind farm by current control.

According to an aspect of the present invention, a method for operating a wind farm is proposed, said method comprising the steps of measuring the grid frequency with a sensor unit, transmitting said measured grid frequency to a control unit, determining whether the measured grid frequency lies outside a predetermined range, and, if the measured grid frequency lies outside said predetermined range, selecting at least one out of the at least two wind turbines comprised in said wind farm by said control unit and regulating the power output of said selected at least one wind turbine.

The above described method allows for a centralized wind farm control and, thus, a centralized wind farm management. Since the management occurs at the highest, i.e. at the wind farm level, the proposed method allows for high dynamics and variable use in the regulation to stabilize grid parameters like, e.g., grid frequency. Furthermore, since the central wind farm management has access to the operational data of each of the wind turbines comprised in the wind farm, the centralized wind farm management may be optimized with respect to various parameters. Thus, not only frequency stabilization may be considered when selecting one or more wind turbines to be curtailed, but also other criteria like wear of parts of the turbine, i.e. lifetime considerations, and/or maintenance considerations and/or the (actual) operating or load conditions of individual turbines can be used to select turbines. Thus, the efficiency of the wind farm management can be increased by centralized wind farm management as compared to the uncoordinated control of individual wind turbines within the wind farm.

According to another aspect of the present invention, a method for operating a wind farm is proposed, said method comprising the steps of measuring a first variable representative of said wind farm by said sensor element, transmitting said measured first variable to a coupling device, determining whether the measured first variable lies outside a predetermined range, and if the measured first variable lies outside the predetermined range, selecting at least one out of the at least two wind turbines comprised in said wind farm by said coupling device and regulating the power output of said selected at least one wind turbine by controlling a second variable of said wind farm.

Also, the above described method according to another aspect of the present invention allows for a centralized wind farm control and, thus, a centralized wind farm management. Accordingly, also this method has the advantages already described in connection with the aforementioned operating method. However, the above described method further allows to obtain not only values of grid parameters, but also values of internal parameters of the wind farm, e.g. the actual power delivered to the grid or the actual current or voltage at the point of coupling to the grid. Therefore, the wind farm management can also be based on inherent restrictions of the wind farm or on requirements prescribed by external parties, e.g. utilities or public authorities. For example, the actual power setpoint or the maximum power setpoint can be commanded externally. Only a centralized wind farm management is capable

of observing such requirements. A distributed management based on the independent control of the individual wind turbines comprised in the wind farm may not effectively react to sudden demands related to the stabilization of grid parameters since total output power of the wind farm is not managed coherently. Accordingly, the above described method of centralized control is of a considerably higher flexibility than the independent control of the individual wind turbines.

According to a further aspect of the present invention, a procedure for operating a wind farm is provided, said procedure comprising the steps of operating the wind farm at its maximum total power output while the grid frequency stays within a predetermined range, and reducing the power output according to a method for operating a wind farm according to an aspect of the present invention when the grid frequency exceeds the upper boundary value of said range.

When the wind farm is operated according to the above procedure, maximum gain from the wind farm is obtained since it operates always at maximum output power except for cases where the grid frequency exceeds the upper boundary value of the desired range in which it should remain. In this case, the output power of the wind farm is reduced to stabilize the grid frequency.

According to still another aspect of the present invention, a procedure for operating a wind farm is proposed, said procedure comprising the steps of operating the wind farm at a predetermined power output below the maximum power output of said wind farm while the grid frequency stays within a predetermined range, reducing the power output according to a method for operating a wind farm according to an aspect of the present invention when the grid frequency exceeds the upper boundary value of said range, and increasing the power output according to a method for operating a wind farm according to an aspect of the present invention when the grid frequency undershoots the lower boundary value of said range.

The procedure according to still another aspect of the present invention as described above is especially advantageous when the wind farm is connected to small or unstable grids. In this case, not only the maximum gain from the wind farm is an important issue but also the stabilization of the grid parameters. Therefore, the wind farm operates at partial load even at stable grid

conditions with the right grid frequency to function as a "spinning reserve": If the grid frequency deviates from its setpoint, the power output of the wind farm can be increased or decreased to stabilize the grid frequency. If the grid frequency value rises from the defined setpoint, the real power output of the wind farm will be reduced. On the other hand, the power output will be increased, if the frequency drops. The respective shift of the real power output by centralized control of the wind farm thus counteracts the grid frequency variations.

Brief Description of the Drawings

Fig. 1 is a schematic view of a wind farm according to an embodiment of the present invention.

Fig. 2 is a schematic view of a wind farm according to a further embodiment of the present invention.

Fig. 3 is a schematic view of a wind farm according to another embodiment of the present invention.

Fig. 4 shows the interrelated variation of grid frequency and real power output according to a procedure for operating a wind farm according to an aspect of the present invention.

Fig. 5 shows the interrelated variation of grid frequency and real power output according to a procedure for operating a wind farm according to another aspect of the present invention.

Fig. 6 shows the variation of real power output according to a method for operating a wind farm according to an aspect of the present invention.

Fig. 7 shows the variation of real power output according to a further method for operating a wind farm according to a further aspect of the present invention.

Detailed Description

Fig. 1 is a schematic view of a wind farm according to an embodiment of the present invention. The wind farm comprises wind turbines 1, 2, 3, 4 which are connected to a power grid. The wind farm further comprises a centralized control unit 5 which is connected to each of the wind turbines 1, 2, 3, 4. The control unit 5 is adapted to individually select and control the wind turbines 1, 2, 3, 4 of the wind farm. Since the control of wind turbines 1, 2, 3, 4 can be remote, control unit 5 can be placed within or outside the wind farm. Furthermore, a sensor unit 6 is comprised by the wind farm, said sensor unit 6 being connected to said power grid and to said control unit 5. The sensor unit 6 is adapted to measure a relevant grid parameter, e.g. grid frequency. However, also other grid parameters can be used if appropriate. Hereinafter, grid frequency is exemplary used as the measured grid parameter. The grid frequency can be measured at any point within the wind farm or outside of the wind farm. This can be done at a substation or at an individual wind turbine or a remote point of the grid, i.e. sensor unit 6 may be formed as a substation or may be integrated into an individual wind turbine of the wind farm

In the following, the operation of the above wind farm is described with reference to Figs. 6 and 7. As mentioned above, the grid frequency rises if there is more power fed to the grid than is consumed and, vice versa, the grid frequency drops if there is more power consumed than is supplied to the grid. To maintain a desired grid frequency, e.g. 60Hz for the USA and 50 Hz for Germany, it is desirable to control the actual power output of the wind farm. This control effects that the real power output of the wind farm will be reduced if the grid frequency value rises over a predetermined upper boundary value. There are several possibilities for reducing the actual power output, namely by shutting down individual wind turbines within the wind farm and/or by reducing the power output of individual wind turbines gradually and/or by reducing the power output of individual wind turbines continuously. In the opposite case, i.e. if the grid frequency falls below a predetermined lower boundary value, increased wind farm power output would be required to stabilize the grid. The increase of actual power output can be effected by the control by starting up one or more wind turbines within the wind farm and/or by increasing the power output of individual wind turbines gradually and/or by increasing power output of individual wind turbines continuously. However, when the wind farm is already operated at full power output, this mode of grid stabilization is not possible.

Fig. 6 shows the variation of the actual output power of the wind farm when it is controlled by continuously increasing or decreasing the power output of individual wind turbines. In contrast to this, Fig. 7 shows the variation of the actual output power of the wind farm when it is controlled by gradually increasing or decreasing the power output of individual wind turbines. A curve like in Fig. 7 may be obtained when shutting down or starting individual wind turbines instead of only decreasing or increasing their power output. In this case, the "upward" steps in the curve in Fig. 7 originate from wind turbines being started, whereas the "downward steps" originate from wind turbines being shut down.

As described above, the output of real power of the wind farm is regulated or controlled according to the measured grid frequency. The grid frequency is measure by sensor unit 6 which transmits the measured grid frequency value to control unit 5. This transmission may occur by any wireless or wire bound means. The centralized control unit 5 regulates the actual power output of the wind farm. In a first step, it determines whether the actual grid frequency is within a predetermined frequency range. If the grid frequency is outside this range, the control unit selects one or more wind turbines to be controlled. The selection criteria that would be used to select a turbine for shut down or reduced operation could be wear of parts of the turbine (life time considerations) and/or maintenance considerations and/or bad operating or load conditions of the individual wind turbine. On the other hand, the same selection criteria would be used to select a turbine for starting up or increased operation but with reversed signs. The control of the individual turbines can be accomplished by curtailing the wind turbines by, e.g., varying the pitch angle or even feathering the rotor blades.

Next, a further embodiment of the present invention is described with reference to Fig. 2 which also shows a wind farm comprising several wind turbines 1, 2, 3, 4. In this embodiment, the wind turbines are not directly coupled to the power grid but are connected via a coupling device 7. The wind farm further comprises a sensor element 8 for measuring a variable of the wind farm. Such a variable indicative of the state of the wind farm can be, e.g., the actual power output or current of the wind farm or the actual voltage at the point of coupling to the power grid. The wind turbines 1, 2, 3, 4 are connected to coupling device 7 via sensor element 8 whereby sensor element 8 is arranged outside the coupling device 7. However, the sensor element 8 can also

be integrated into the coupling device 7, similar to the embodiment shown in Fig. 3.

In operation, sensor element 8 measures a variable indicative of the internal state of the wind farm, e.g., the total power output. It then transmits the measure power value to the coupling device 7 which then checks whether the measured power value is within a predetermined range of power values or at a predetermined setpoint. For example, a network operator may prescribe a certain maximum power output for the wind farm which is smaller than the full capacity of the wind farm. In this case, the power output of the wind farm must be regulated to maintain the maximum power value. In case coupling device 7 detects a deviation from the predetermined desired values, it selects one or more wind turbines 1, 2, 3, 4 from the wind farm and reduces or increases their individual power output. Regarding the control of individual wind turbines, reference is made to the above explanations. However, it is to be mentioned that in the present embodiment, the control of the power output may be accomplished by controlling an internal variable of the wind farm, e.g. by current control. Particularly, when controlling the selected wind turbine(s) by an internal variable, e.g. the current output of each individual selected wind turbine or the voltage at the point of coupling to the grid is controlled and regulated.

It should be understood that the features of the first and second embodiments described above can be combined to achieve further advantageous effects. For example, a wind farm may comprise a sensor unit for sensing a grid parameter as well as a sensor element for sensing an internal variable of the wind farm. Furthermore, not only one but more external, i.e. grid, and internal variables can be sensed by additional sensors provided in a wind farm according to an embodiment of the present invention.

Finally, two different procedures for operating a wind farm according to two different aspects of the present invention are described with reference to Figs. 4 and 5.

Fig. 4 shows the interrelated variation of frequency and power output when the wind farm is operated according to a first procedure. According to this procedure, the wind farm is operated at its maximum total power output while the grid frequency stays within a predetermined range. If, however, the grid frequency exceeds the upper boundary value of said range, the power

output of the wind farm is reduced according to any of the aforementioned methods for operating a wind farm. Since the wind farm operates at its maximum power output, it cannot counteract to frequency drops (which require additional power output) but only to a rise in frequency.

Fig. 5 shows the interrelated variation of frequency and power output when the wind farm is operated according to a second procedure. According to this procedure, the wind farm is operated at a predetermined power output below the maximum power output of said wind farm while the grid frequency stays within a predetermined range. If, however, the grid frequency exceeds the upper boundary value of said range, the power output is reduced according to any of the aforementioned methods for operating a wind farm, and, if the grid frequency undershoots the lower boundary value of said range, the power output is increased according to any of the aforementioned methods for operating a wind farm. This operation mode can also stabilize the grid within a wind farm that is not connected to the public grid (isolated grid). This operation mode can also stabilize a weak grid, where the installed wind farm power is a substantial part of the installed power of the generation units of the grid. For example with wind diesel applications or bio gas motor/wind, solar/wind or any combination of above.

Claims

1. A wind farm with at least two wind turbines (1, 2, 3, 4) connected to a power grid, further comprising

a control unit (5) connected to said at least two wind turbines (1, 2, 3, 4), and

a sensor unit (6) connected to said power grid and said centralized control unit (5),

wherein said sensor unit (6) is adapted to measure the grid frequency of said power grid and to transmit said measured grid frequency to said control unit (5), and

wherein said control unit (5) is adapted to control the output of real power of said wind farm according to said measured grid frequency.

2. The wind farm according to claim 1, wherein said sensor unit (6) is a separate substation or integrated into one of said at least two wind turbines (1, 2, 3, 4).

3. The wind farm according to claim 1 or 2, wherein said control unit (6) is adapted to shut down individual wind turbines within the wind farm.

4. The wind farm according to any of the preceding claims, wherein centralized control unit (6) is adapted to gradually and/or continuously reduce the power output of individual wind turbines within the wind farm.

5. The wind farm according to any of the preceding claims, wherein said control unit (6) further comprises a selection unit for selecting individual wind turbines (1, 2, 3, 4) within said wind farm.

6. The wind farm according to any of the preceding claims, wherein said sensor unit (6) is adapted to transmit said measured grid frequency to said control unit (5) by radio, optical, sound or electrical signal means.

7. A wind farm with at least two wind turbines (1, 2, 3, 4) connected to a power grid, further comprising

a coupling device (7) for coupling the wind farm to the power grid, and

a sensor element (8) for sensing a first variable representative of said wind farm

wherein said sensor element (8) is adapted to transmit said measured first variable to said coupling device (7), and

wherein said coupling device (7) is adapted to control a second variable of said wind farm according to said measured first variable.

8. The wind farm according to claim 7, wherein said sensor element (8) is integrated into said coupling device (7).

9. The wind farm according to claim 7 or 8, wherein said first variable is the actual power output of the wind farm, the actual output current of the wind farm or the actual voltage at the point of coupling to the power grid.

10. The wind farm according to any of claims 7 to 9, wherein said second variable is the total current output of the wind farm.

11. The wind farm according to any of claims 7 to 10, wherein the coupling device comprises semiconductor switching devices for controlling the power output of said wind farm.

12. The wind farm according to any of claims 7 to 11, further comprising the features of any of claims 1 to 6.

13. A method for operating a wind farm according to any of claims 1 to 6, said method comprising the steps of:

measuring the grid frequency with a sensor unit,

transmitting said measured grid frequency to a control unit,

determining whether the measured grid frequency lies outside a predetermined range, and

if the measured grid frequency lies outside said predetermined range, selecting at least one out of the at least two wind turbines comprised in said wind farm by said control unit and regulating the power output of said selected at least one wind turbine.

14. A method for operating a wind farm according to any of claims 7 to 12, comprising the steps of:

measuring a first variable representative of said wind farm by said sensor element,

transmitting said measured first variable to a coupling device,

determining whether the measured first variable lies outside a predetermined range, and

if the measured first variable lies outside the predetermined range, selecting at least one out of the at least two wind turbines comprised in said wind farm by said coupling device and regulating the power output of said selected at least one wind turbine by controlling a second variable of said wind farm.

15. The method according to claim 14, wherein said second variable is the current output of said selected at least one wind turbine or the actual voltage at the point of coupling to the grid.

16. The method according to any of claims 13 to 15, wherein the criteria for selecting the at least one wind turbine are life time and/or maintenance considerations and/or operating or load conditions of an individual wind turbine.

17. The method according to any of claims 13 to 16, wherein the selected at least one wind turbine is shut down or started.

18. The method according to any of claims 13 to 16, wherein the controlled variable, especially power output, current output or voltage at the point

of coupling to the grid, of said selected at least one wind turbine is reduced or increased gradually.

19. The method according to any of claims 13 to 16, wherein the controlled variable, especially power output, current output or voltage at the point of coupling to the grid, of said selected at least one wind turbine is reduced or increased continuously.

20. A procedure for operating a wind farm, comprising the steps of:

operating the wind farm at its maximum total power output while the grid frequency stays within a predetermined range, and

reducing the power output according to a method of any of claims 13 to 19 when the grid frequency exceeds the upper boundary value of said range.

21. A procedure for operating a wind farm, comprising the steps of:

operating the wind farm at a predetermined power output below the maximum power output of said wind farm while the grid frequency remains within a predetermined range,

reducing the power output according to a method of any of claims 13 to 19 when the grid frequency exceeds the upper boundary value of said range, and

increasing the power output according to a method of any of claims 13 to 19 when the grid frequency undershoots the lower boundary value of said range.

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AMENDED CLAIMS

[received by the International Bureau on 22 September 2004 (22.09.2004); original claim 1-21 replaced by amended claims 1-18]

1. A wind farm with at least two wind turbines (1, 2, 3, 4) connected to a power grid, further comprising

a coupling device (7) for coupling the wind farm to the power grid,

a sensor element (8) for sensing a first variable representative of said wind farm, wherein said sensor element (8) is adapted to transmit said measured first variable to said coupling device (7),

a control unit (5) connected to said at least two wind turbines (1, 2, 3, 4), and

a sensor unit (6) connected to said power grid and said centralized control unit (5), wherein said sensor unit (6) is adapted to measure the grid frequency of said power grid and to transmit said measured grid frequency to said control unit (5), and

wherein said coupling device (7) is adapted to control a second variable of said wind farm according to said measured first variable, and

wherein said control unit (5) is adapted to control the output of real power of said wind farm according to said measured grid frequency, and

2. The wind farm according to claim 1, wherein said sensor unit (6) is a separate substation or integrated into one of said at least two wind turbines (1, 2, 3, 4).

3. The wind farm according to claim 1 or 2, wherein said control unit (6) is adapted to shut down individual wind turbines within the wind farm.

4. The wind farm according to any of the preceding claims, wherein centralized control unit (6) is adapted to gradually and/or continuously reduce the power output of individual wind turbines within the wind farm.

5. The wind farm according to any of the preceding claims, wherein said control unit (6) further comprises a selection unit for selecting individual wind turbines (1, 2, 3, 4) within said wind farm.

6. The wind farm according to any of the preceding claims, wherein said sensor unit (6) is adapted to transmit said measured grid frequency to said control unit (5) by radio, optical, sound or electrical signal means.

7. The wind farm according to any of the preceding claims, wherein said sensor element (8) is integrated into said coupling device (7).

8. The wind farm according to any of the preceding claims, wherein said first variable is the actual power output of the wind farm, the actual output current of the wind farm or the actual voltage at the point of coupling to the power grid.

9. The wind farm according to any of the preceding claims, wherein said second variable is the total current output of the wind farm.

10. The wind farm according to any of the preceding claims, wherein the coupling device comprises semiconductor switching devices for controlling the power output of said wind farm.

11. A method for operating a wind farm according to any of claims 1 to 10, said method comprising the steps of:

measuring a first variable representative of said wind farm by said sensor element,

measuring the grid frequency with a sensor unit,

transmitting said measured first variable to a coupling device,

transmitting said measured grid frequency to a control unit,

determining whether the measured first variable lies outside a predetermined range, and, if the measured first variable lies outside the predetermined range, selecting at least one out of the at least two wind turbines comprised in said wind farm by said coupling device and

regulating the power output of said selected at least one wind turbine by controlling a second variable of said wind farm, and

determining whether the measured grid frequency lies outside a predetermined range, and, if the measured grid frequency lies outside said predetermined range, selecting at least one out of the at least two wind turbines comprised in said wind farm by said control unit and regulating the power output of said selected at least one wind turbine.

12. The method according to claim 11, wherein said second variable is the current output of said selected at least one wind turbine or the actual voltage at the point of coupling to the grid.

13 The method according of claim 11 or 12, wherein the criteria for selecting the at least one wind turbine are life time and/or maintenance considerations and/or operating or load conditions of an individual wind turbine.

14. The method according to any of claims 11 to 13, wherein the selected at least one wind turbine is shut down or started.

15. The method according to any of claims 11 to 13, wherein the controlled variable, especially power output, current output or voltage at the point of coupling to the grid, of said selected at least one wind turbine is reduced or increased gradually.

16. The method according to any of claims 11 to 13, wherein the controlled variable, especially power output, current output or voltage at the point of coupling to the grid, of said selected at least one wind turbine is reduced or increased continuously.

17. A procedure for operating a wind farm, comprising the steps of:

operating the wind farm at its maximum total power output while the grid frequency stays within a predetermined range, and

reducing the power output according to a method of any of claims 11 to 16 when the grid frequency exceeds the upper boundary value of said range.

18. A procedure for operating a wind farm, comprising the steps of:

operating the wind farm at a predetermined power output below the maximum power output of said wind farm while the grid frequency remains within a predetermined range,

reducing the power output according to a method of any of claims 11 to 16 when the grid frequency exceeds the upper boundary value of said range, and

increasing the power output according to a method of any of claims 11 to 16 when the grid frequency undershoots the lower boundary value of said range.

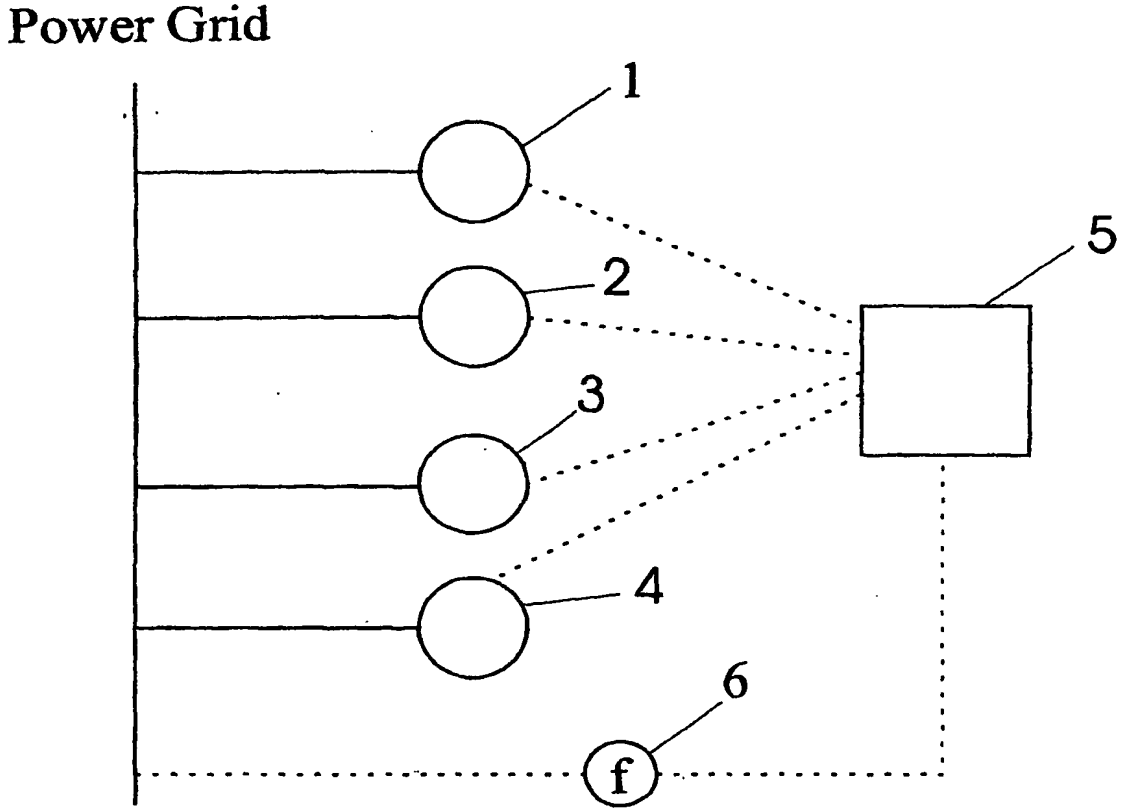

Fig. 1

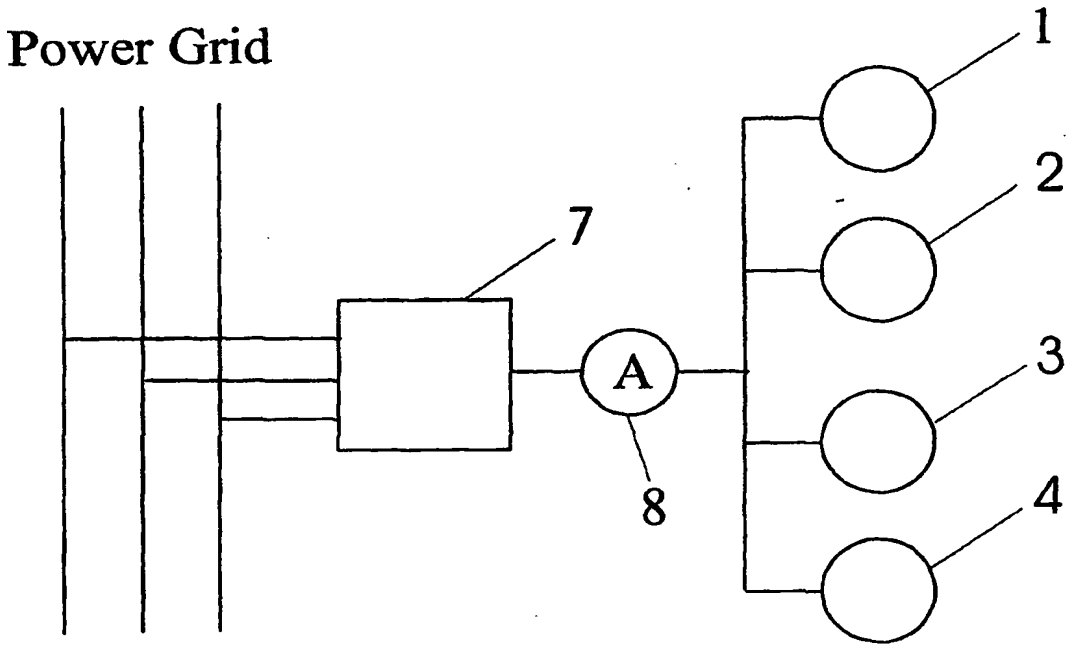

Fig. 2

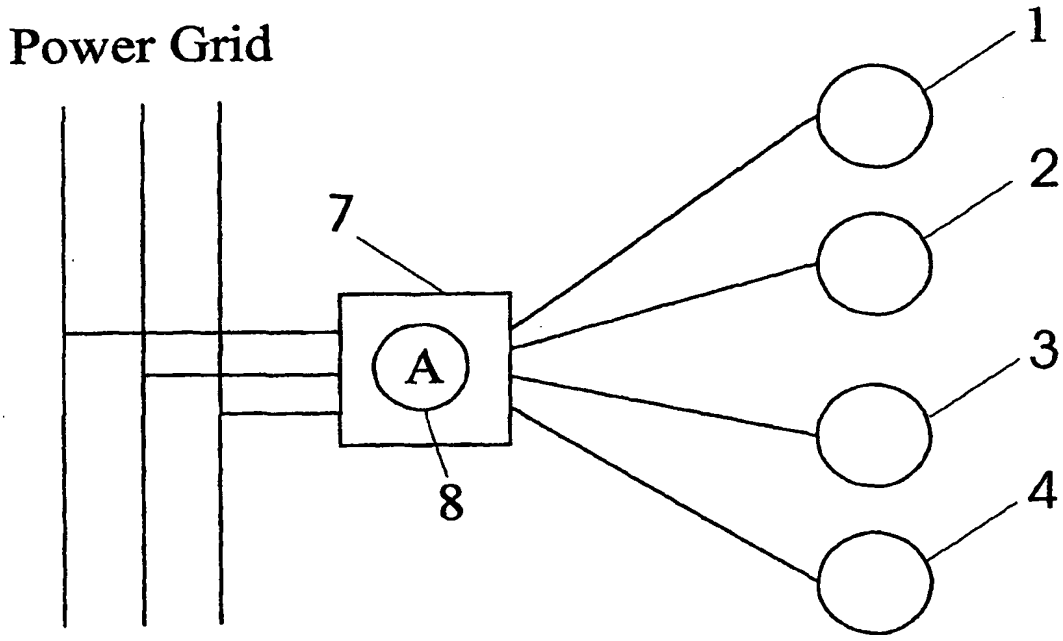

Fig. 3

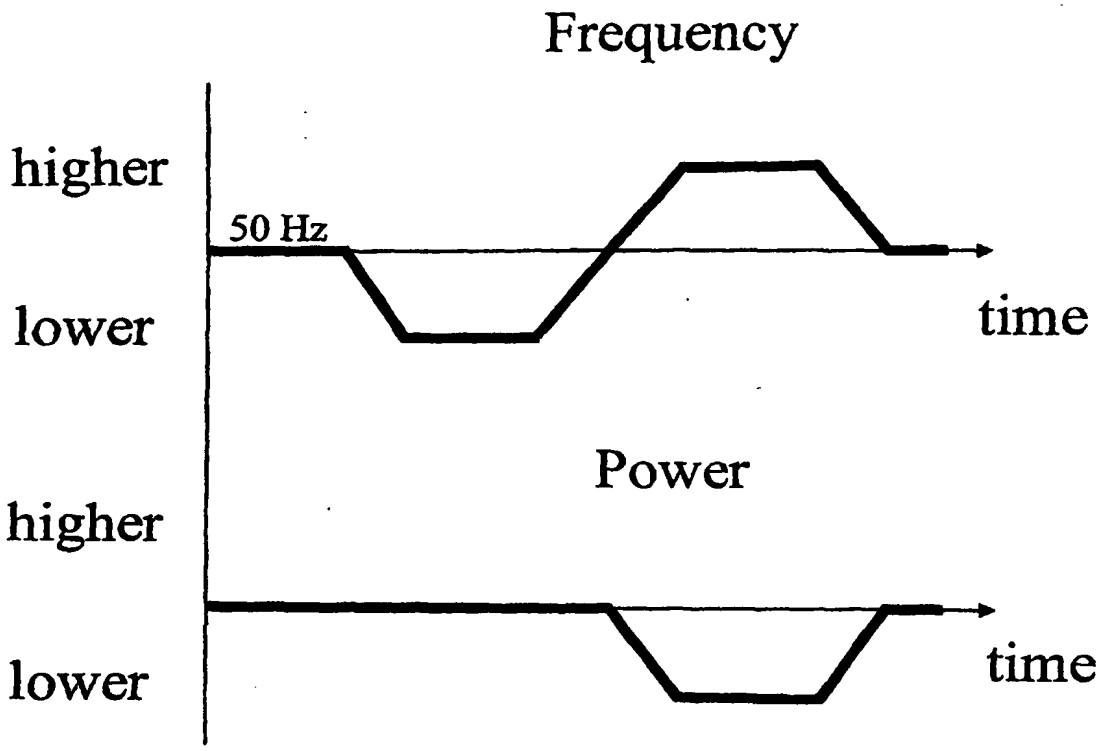

Fig. 4

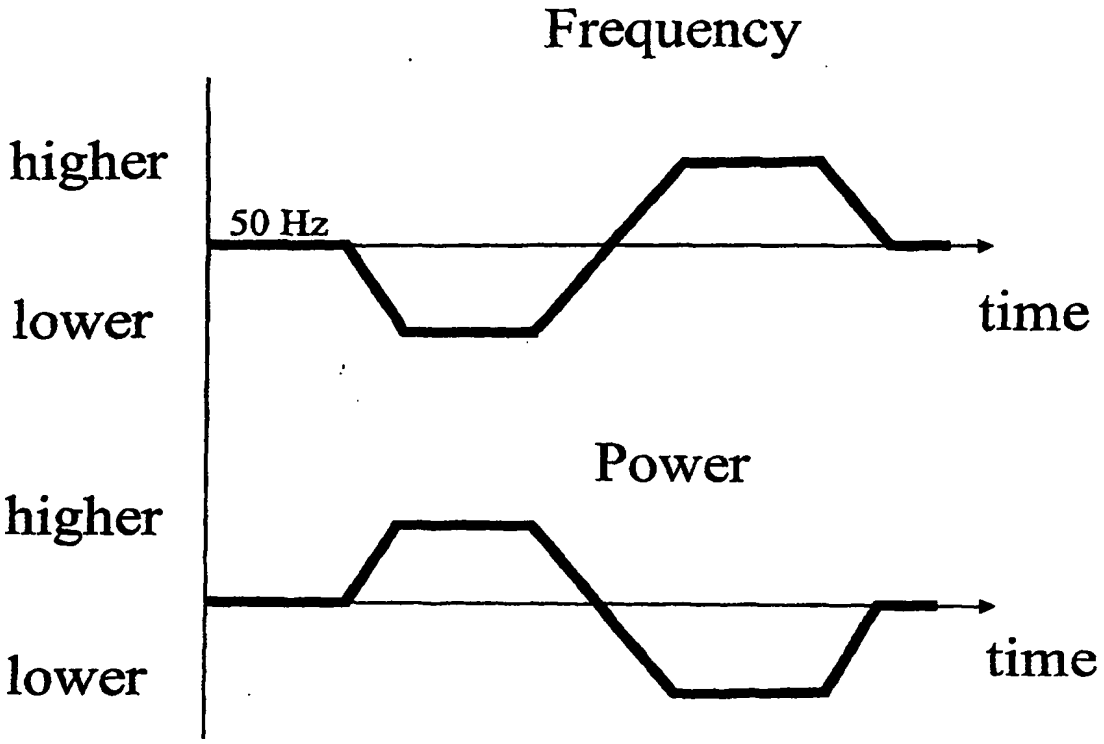

Fig. 5

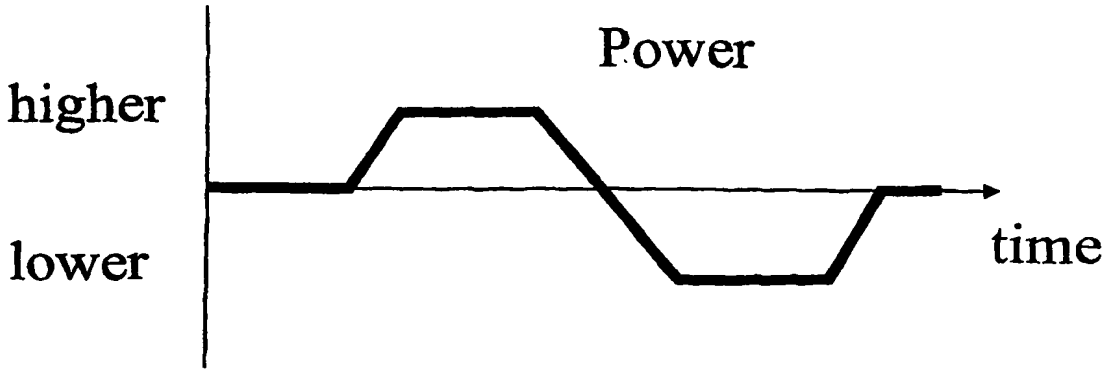

Fig. 6

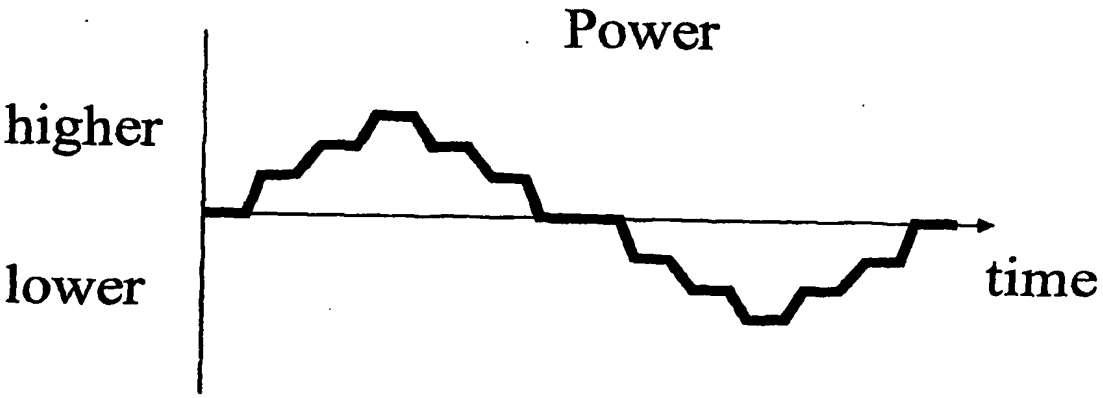

Fig. 7

INTERNATIONAL SEARCH REPORT

International Application No
PCT/EP2004/003804

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 H02J3/38 F03D9/00

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 H02J F03D

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)
EPO-Internal, INSPEC, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
P,X	WO 03/030329 A (WOBBEN ALOYS) 10 April 2003 (2003-04-10) abstract page 14, paragraph 5 - page 18, paragraph 1 page 20, paragraph 4 - page 21, paragraph 1 claims 7,8,10,11,15 -/--	1-21

[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

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"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

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"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

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Date of the actual completion of the international search	Date of mailing of the international search report
13 July 2004	21/07/2004

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Lorenzo Feijoo, S

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INTERNATIONAL SEARCH REPORT

International Application No
PCT/EP2004/003804

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	TAPIA A ET AL: "Modeling and dynamic regulation of a wind farm" 7TH IEEE INTERNATIONAL POWER ELECTRONICS CONGRESS. TECHNICAL PROCEEDINGS. CIEP 2000 (CAT. NO.00TH8529), PROCEEDINGS OF CIEP 2000. 7TH IEEE INTERNATIONAL POWER ELECTRONICS CONGRESS, ACAPULCO, MEXICO, 15-19 OCT. 2000, October 2000 (2000-10), pages 293-297, XP010527924 2000, Piscataway, NJ, USA, IEEE, USA ISBN: 0-7803-6489-9 the whole document	7-9,11, 14
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Information on patent family members

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